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ABSTRACT

The Lexington School for the Deaf (New York) has developed a program which involves deaf students in extensive writing within the science curriculum through utilization of a local area network of linked computers. The program is intended to counter the students' low science achievement and poor written language skills. Originally developed for use in the pre-highschool Earth Science curriculum, the technology was used during 1990 with 10 deaf children (median reading grade level 4.1) in a high school preparatory class. Students used the computers to communicate with the teacher and to complete assignments including logs, summaries, reports, problem solving, story completion, filing, tests, and short-answer quizzes. Several writing measures were used to evaluate children's writing samples: a measure of writing errors, a measure of connectedness in writing, and a number of holistic measures. Analysis of changes in student writing indicated a significant reduction in writing errors and in failures to connect sentences meaningfully. Most errors were errors of reference and location, typical in the writing of the deaf. Includes five references. (DB)

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LITERACY AND SCIENCE: THE DEVELOPMENT OF DEAF STUDENTS' WRITING SKILLS IN NETWORKED SCIENCE CLASSROOMS

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Paper presented at the annual meeting of the American Educational Research Association, Chicago, April, 1991.

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I. Overview

We do not know how many people in the audience are familiar with the old and new in deaf education. Language has been an embattled subject in the deaf community for 200 years and critical educational issues familiar to those in schools for the hard-of-hearing have now become all too familiar in schools for hearing children as well.

Deaf children who graduate from high school have, on the average, reading skills below fifth grade level (Allen, 1986). Many cannot read for pleasure or information seeking, nor can they share ideas through writing. Their limited literacy contributes to keeping the deaf out of the mainstream of education and from significant participation in the workplace. Improving the literacy skills of deaf children is a critical step toward improving their chances in life and toward gaining access to meaningful employment.

We think that we have begun to create an effective literacy environment for deaf children, one where reading and writing become natural forms of communication for both intellectual and

social purposes. In this environment, writing is not a disembodied school activity, but is embedded in a set of purposeful learning activities, and involves students in communication with a number of audiences. We think that a networked system of computers provides the technological support for such an environment.

All educators are now facing problems in the area of literacy. In using the word "literacy" here, we mean fluency in reading and writing English. This problem is both ancient and stubborn in the deaf and hearing-impaired population we serve. In addition to problems in literacy, there are also problems of low science achievement. These problems of poor literacy and science skills are evident in the hearing population as well (NCEE, 1983). At Lexington, we decided to attack both problems by immersing deaf students in print through a relatively new technology now available for education, a system of linked computers in a local area network. The Center for Children and Technology at the Bank Street College of Education developed the software to aid in the teaching of Earth Science. The system has been used in inner-city schools (Newman, 1987), but has not been tested with deaf students.

A. Rationale

We address, then, two major problems. The stated foreground problem is low science achievement. The constant background problem is the impenetrability of written English for deaf

students. To attack these problems, it is necessary to redefine the teaching approach so that interactions on the computer can take place via a Local Area Network. This proposed change led us to two questions:

1. Will students and teachers accept the new environment as a medium of interaction and instruction?
2. Will immersion in print increase literacy skills even though these are not language classes?

A computer network links work stations together so that a person at one machine can communicate and share information with a person at any other machine. Typically, networks have software programs for word processing, for sending and receiving mail inside and outside of an organization, and for data storage and analysis. They make it possible for people to share ideas, information, and the work of gathering and interpreting data. While common in the business and scientific worlds, networks are not yet widely used in schools. However, the technology has great promise for supporting written communication and collaboration in schools.

The LAN is a tool that allows for independent work by the student and is adaptable to large numbers of students. There is no prescribed goal of the software. The teacher must provide content and must structure the way students interact with it. With the LAN, the teacher is the active mediator of the students' progress towards the goal of topic knowledge. The network also

allows for interaction between the students and the teacher outside of the context of the lesson. We now have a scientist and two teachers helping the students to implement studies of the moon and sun with the earth science classes. They use the network to share data and ideas, and to integrate and communicate their thoughts about the experiments they conduct.

At first we were uncertain about the level of change in learning to expect for students using the network. Originally, we planned to look for change in overall science grades and even for changes in reading and science standard scores, although there was not a high expectation of the latter. Eventually we will want to see evidence of that kind of broadbased change in learning as refinements in the connection between the network and the curriculum become clear. At any rate, we were encouraged and surprised when 11 out of our original 13 pilot chilren showed improved science grades, a testament, we think, to the excitement generated by the original project. That finding, unfortunately, did not hold up the following year. Improvements at the more general level still await the development of more specific connections between tasks, cognitive structures, and measurement instruments. We do, however, look for and find changes in the more refined measures of literacy, particularly in writing achievement which we will discuss shortly.

B. Brief Description of the Network

The computer network installed at Lexington School for the

Deaf has several interactive components. Originally the software included the Bank Street Writer and Bank Street Filer on a CORVUS network. We recently switched to an APPLE network. Students log onto the Apple II GS computers as individuals or as a group. As a function of the way students have logged on, they can access individual, paired, or group data files. Originally, teachers tended to use the group workspace for the day's lesson especially when working with data sets where all the students needed to have access to the same data set. Later, the configuration changed, and each of the three science teachers had a terminal in their rooms as well. A video switcher was also added.

An important difference between the networked and traditional classrooms is that the student is more immediately and constantly involved with the learning process in the networked classroom. Of course, the networking system may not lend itself to all subject areas equally. It is admirably suited to those subject areas that use the sorting and organizing of large data sets to illustrate important points. It also can be used in all subject areas where immediate feedback is desired, e.g., review and questions, and in situations where general information is provided to all students in a class. The networking system reduces class start-up time and repetitions by the teacher and allows for more individual attention and curriculum related collaboration between the students.

Here are some comments relevant to questions raised by the

introduction of networking in a school:

1. Regarding the feasibility of this technology in a school for the deaf, we have been generally pleased. The network was installed linking 8 Apple II GSs and the teachers have used it to implement parts of their regular curricula with minimal training. Another (IBM) network has been added in the high school. Students also have experienced very little difficulty learning how to use the networks and show great facility switching from one to the other. Both networks are used in a variety of classroom and extracurricular activities.
2. Regarding modifications to the original system, no software modifications were necessary. A video switcher which allows the teacher to control individual screens was added to enhance the original system. This proved to be an invaluable tool for our teachers in helping to maintain control in the classroom and in focussing the attention of the students. We have also replaced the CORVUS network with a more efficient and serviceable APPLE network. The installation of this new network has been accomplished with relative ease for both students and teachers.
3. With regard to support within the school, the project's first two teachers are still strong supporters of the

technology and continue to integrate the system into their plans for teaching earth science. A third teacher volunteered to use the system in a one-term technology course he teaches and is quite creative in devising unique and seductive uses for his seventh and eighth-grade students. The administration is supportive of our system both as a research project and as an integrated teaching tool in the high school.

While we know and believe that statistics are important, we also know that a successful experience, as defined by one student, is also real and important. Her words, exactly as they were written (below), carry significant meaning. The research staff asked students if they did or did not like using the network. One student's answer to this question which we often quote may offer insight into the question:

DEAR MS. SMITH,

THANKS FOR YOUR LETTER AND I COULD APPERATICATE YOUR QUESTIONS THEN I ACCPET TO ANSWERS YOUR SOME QUESTIONS.

I REALLY LIKE TO BE WITH COMPUTPERS BECAUSE I USED IT IN MY HOME EVERYDAY IT GAVE MY MIND GROW A GOOD EDUCATION. I HATE IS LEAVING THE COMPUTERS ROOM TO GO THE CLASS BECAUSE OF COMPUTERS CAN TEACH ME EASILY TO UNDERSTAND AND STORAGE THE MESSAGE THAN Y TEACHER'S SPEAKING TO LOST MY MEMORY.

I WOULD LIKE TO SEE YOUR VIDEO TAPE THAT YOU USED US THE CLASS IN COMPUTER YOUR VIDEO CAMERA..CAN WE BORROW ONE

OF YOUR VIDEO FOR WATCHING WHAT WE ARE DOING HUH??? THANKS!

OR SIIIIGGHH.....

II. Writing on the Network

We'd like to talk now about some of the aspects of literacy we're exploring for students who use the computer networks at Lexington. We'll tell you a little bit more, first of all, about the exposure the children have had to networking.

The original network was established for use in the pre-high-school Earth Science curriculum. Two teachers were initially involved, both responsible for the same state-mandated earth science curriculum, and a third teacher uses the network to teach a single-term technology course. While the material the teachers present is mandated by the state, their use of the network is at their discretion. The feeling on our part is that the teachers are the experts in the design of their own curriculum and, while some direction might facilitate *particular* uses of the computer, teachers are best left alone to fashion what they teach. And the teachers are quite creative in their use of the network. In addition to choosing and designing their own curriculum, teachers also choose whether or not they will use the network altogether.

In deciding to allow the teachers to control the use of the network, we've given up quite a bit of experimental control. That is, we have given up control over *which* students use the

network in allowing teachers the option to use it or not, and, to some extent, *the amount* that those students use the network in allowing teachers to design their own programs for use. We do tend to get the more able children in our network program and probably the more able teachers as well, or at least the more adventuresome, but we think that the changes we talk about are not due entirely to student and teacher abilities, nor do we want to underestimate those. Our data suggests that less able children stand to benefit from networking as much or more than do more able children.

The subject group consists of ten deaf children in a high-school preparatory class (between eighth and ninth grades) with, just to give you a reference point, a range of reading scores from 3.4 to 8.2, the median being 4.1. Figure 1 will give you a quick summary of what we mean when we talk about "use" of the network.

[FIGURE 1]

Most of the communication on the network is between student and teacher and is related to schoolwork..."High use" means around 200-300 lines of text generated per student whereas "low use" is around 65-75 lines on the average. We'll be talking about the "1990" kids today.

We'll use several writing measures to analyze children's samples-- a measure of writing errors, a measure of connectedness in writing, and a number of holistic measures. What we want to

do with these measures is try to explain the change that we see in writing which is represented in this sample from one of the network students.

[FIGURE 2]

We think the change from the fall sample to either of the spring samples is substantial in terms of readability and in conveying meaning, and we've tried to find and develop measures which describe what makes that so. The difference between the two samples, by the way, has reference to the extent of control present in the writing assignment. The bottom sample, which we've called "structured," were specific class assignments, so a topic and discourse structure were provided. Unstructured samples were summary-type samples: "Tell me what you learned today" or "Tell me what you know about X."

The error measure is simply a count of the number (and type) of error produced in a sample, conditional on the number of words produced. So, for total writing errors, we're talking about a ratio of errors to production in writing. This measure shows a reliability of about 79% agreement between raters. These are the categories of errors we've used...and the general distribution of errors so far looks something like this...

[FIGURE 3]

The bulk of the errors for these children are morphological errors, or errors of reference and location. This is a typical error pattern in the writing of the deaf. The sense that one

gets from the students' writing is that content words are being arranged or rearranged in what the student perceives to be proper English-language order, and that syntactic place markers are either left open or filled from the bag of place markers that applies--You can imagine the children saying, "I need a preposition here, an article goes here, I'll start with an indefinite pronoun, I'll stick an ending on this verb--let me go to the bag and get one"--although not with those labels, necessarily.

We haven't found any significant deviation from this pattern of errors for any of the children we have looked at so far, nor does the distribution change from pre- to post-test for individual children over time as yet [X2 alpha=.05]. We do expect that we might see changes in error patterns as use on the computers increases or, more importantly, as we refine the connections between specific uses of the computer and target behaviors.

At this point we do see an overall reduction in writing errors from pre- to post-test which is most marked for the children who were in the HIGH USE group...

[FIGURE 4]

The left panel shows the change from pre-test to both post-test scores for the high use group. The difference between the pretest and the structured posttest is significant ($p = .05$) and there is some suggestion in the panel on the right that the HIGH

USE group is showing more of an effect for this measure than those who were on the network less. This particular interaction is not significant. There's a lot of variability in the data for this measure and with the small N, it's hard to say exactly what is going on here. But, we do have strong corroborating evidence from the holistic measures to support this type of effect in the writing results generally--that is, more change for the high-use group vs. minimal change for the low-use group...

[FIGURE 5]

We had two outside scorers use the ESL Composition Profile to judge these same writing samples. The ESL profile is based on subjective ratings of the pieces in five areas--content, organization, vocabulary, language use, and mechanics. All of these ratings correlated significantly with our measures and, in addition, the high use group showed significant change from pre- to post-test in all of the measures except vocabulary. The low use group showed no differences in any of the measures.

Let me talk now about connectedness in writing and tell you how the children fare in this respect. The measure we're using is one we've adapted from McCutchen & Perfetti (1982) who adapted it from Halliday and Hasan (1976). McCutchen and Perfetti used this measure in a developmental study with hearing children and we'll show some of their data today for reference.

Connectedness reflects the way that semantic unity is expressed in the connections between sentences or clauses in a

written text. A connection is made between sentences or, more properly, independent clauses, to the extent that given information in one sentence or independent clause is semantically related to information provided is a previous sentence or clause. Here's an example of hearing childrens' writing...

[FIGURE 6]

A LOCAL connection is made when a connection of information holds for adjacent sentences or clauses...a REMOTE connection is made when that sort of relationship holds for a sentence or clause further back in the text, most often to the topic sentence...and FAILURES TO CONNECT occur when no new information is provided or, more importantly, when the attempt to join information in two sentences fails. This can happen when the meaning in one or the other of the sentences being connected is unclear or ambiguous or contradictory, as it is in this sample. The examples I'm showing from hearing childrens' writing are straightforward, I think, although all of these classifications are based on the subjective judgments of the raters. McCutchen and Perfetti report reliabilites between 88 and 94 percent for the hearing childrens' samples on this measure.

We don't want to claim that making these sorts of judgments is *exactly* the same for samples from hearing and deaf children. The written language of deaf individuals is notoriously difficult to parse. Nevertheless, we think we have negotiated a workable adaptation of the coherence measure to writing samples from our

children. Here is a sample of connectedness judgments for the deaf children...

[FIGURE 7]

Our interrater reliability for the samples from the deaf children is 80% using a strict criterion (exact matches to local, remote, failed) and 90% with a lenient criterion (success or failure of each connection). These are samples from deaf children who were asked to describe their activities in science class. They were building a topographic map. Notice that the connectedness rating as we used it for our deaf children can be insensitive to syntax although there must be enough syntactic structure to hold the meaning.

The developmental pattern one looks for in connectedness for hearing children is a trend toward more local connections as children get older. Younger hearing children tend to construct texts replete with remote connections-- usually a topic sentence followed by a list of supporting sentences. In the writing of our deaf children is a change from a majority of failed connections to more successful local connections is more typical-- not developmental change, in this case--or if so, only on the short run throughout the course of a school year. Our childrens' samples haven't shown the list-like structures typical of younger hearing children -- which suggests, perhaps, that our deaf children may not be delayed so much in the development of the structures which mark more sophisticated writing as they are

limited in the use of the linguistic devices that make these structures apparent. Our hope, of course, is that lots of exposure to the language will help remediate that limitation. Here are some results...

[FIGURE 8]

This figures shows increase in local connections. Our deaf children are on the left--these are the children in the high-use group only--and the developmental data for the hearing children are on the right. We were surprised at the similarity of the two curves -- the change in the deaf children during the school year paralleled the developmental change from second to eighth grade in the hearing children very closely. The increase in local connections is marginally significant ($p < .10$). And the same sort of pattern is evident in the reduction in failures to connect...

[FIGURE 9]

In fact, it's even more extreme. The change in failures to connect is significant at the .01 level.

The writing results are very encouraging. It's difficult to capture the experience of reading the first entries of the children writing on the network and reading their last writing assignments. In many cases, this is an experience of almost no understanding of what is being said to close to perfect understanding. Some of the typical characteristics of the writing of the deaf are still evident--misuse of prepositions and

auxiliary verbs, and the like--but there is no question that the writing is more coherent, that attention is paid to connecting one piece of information to another, and that attention is paid to the forms of English that allow the subtlties of meaning to be conveyed.

Also, we think that the significant reduction in writing errors and in failures to connect sentences meaningfully in our children who have used the computer network extensively is a real one, and one which, to some extent at least, depends on the childrens'interaction with English and with their production of language on the network. We don't claim that this experience can't be gotten in other ways. But networking provides a tool for writing and interacting in English that is new and exciting for these children. Computers are not just pencils for them. Computers are pencils, dictionaries, editors, encyclopedias and telephones, among other things. Once the initial task of learning to use the computer is accomplished, and this seems to happen with relative ease despite technical problems and the like, networking removes the onerousness of the writing task for these children who have tremendous difficulty facing it. Computers serve to place writing in a different realm, especially for our children who use the computer network in the context of science learning--a realm in which they've experienced other successes and pleasant learning experiences. Writing is just one of many things the children can do on the computer. And one

which they can learn to do, we think, with some confidence and some expertise.

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FIGURE 1

Computer Use

	1990	1989
Teacher-to-Class (Number of Messages)	28	45
Assignment Types:		
Logs	-	Weekly
Summaries	-	6
Reports	4	1
Problem-Solving	2	1
Complete-a-Story	2	-
Filer	3	12
Tests	1	3
Short-Answer/Quizzes	13	15
Other	3	8
Student Use (Number of Lines)		
Mean	151.90	70.40
Range	15-305	21-103
S.D.	90.70	30.34

FIGURE 2

Change in Writing

Fall - Weekly Science Log

i learn density about ball annd paper clip. density inside paper clip or other thing. ball inside is nothing that what I learn [end of text]

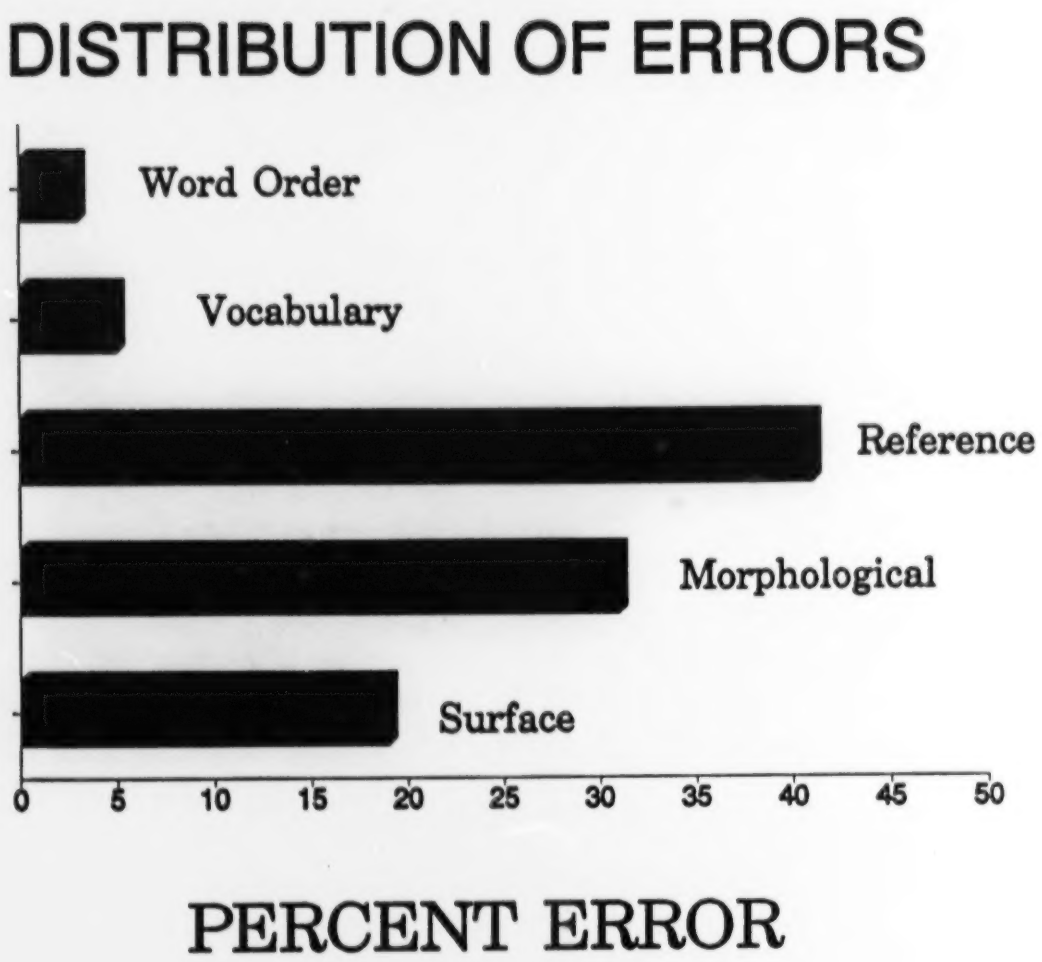
Spring - Weekly Science Log

I learn many things about the moon we went to the roof and to see how far and where in sky. I ask many questions to teacher and how moon show to earth and who first touch the moon and how much gravity moon has. . . [goes on]

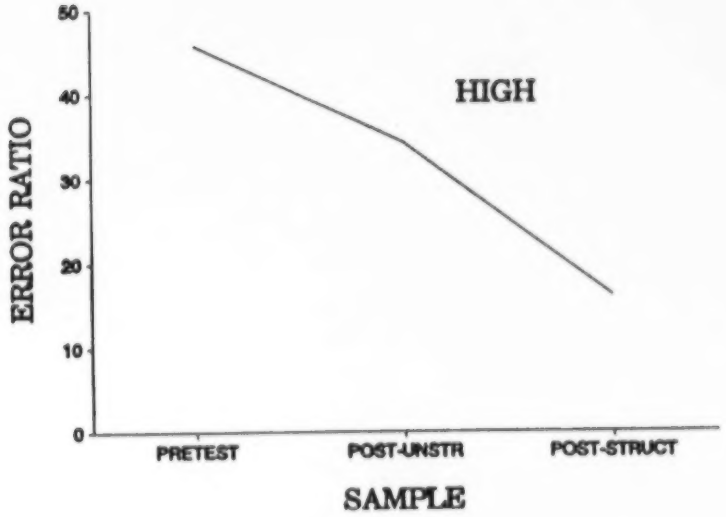
Spring - Letter to Student

I love sports. I always came home after school and play football in the fall and winter. In spring I play football and baseball. In summer I always go swimming. . .[goes on]

FIGURE 3


DISTRIBUTION OF ERRORS
Word Order
Vocabulary
Reference
Morphological
Surface
0
5
10
15
20
25
30
35
40
45
50
PERCENT ERROR

WRITING ERRORS



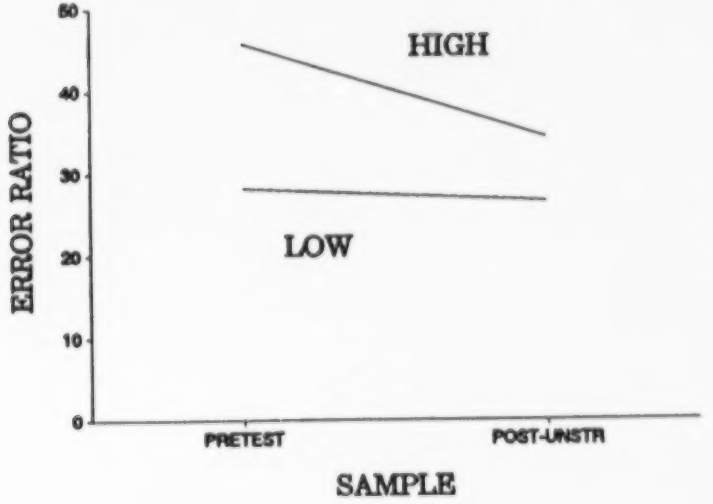


FIGURE 4

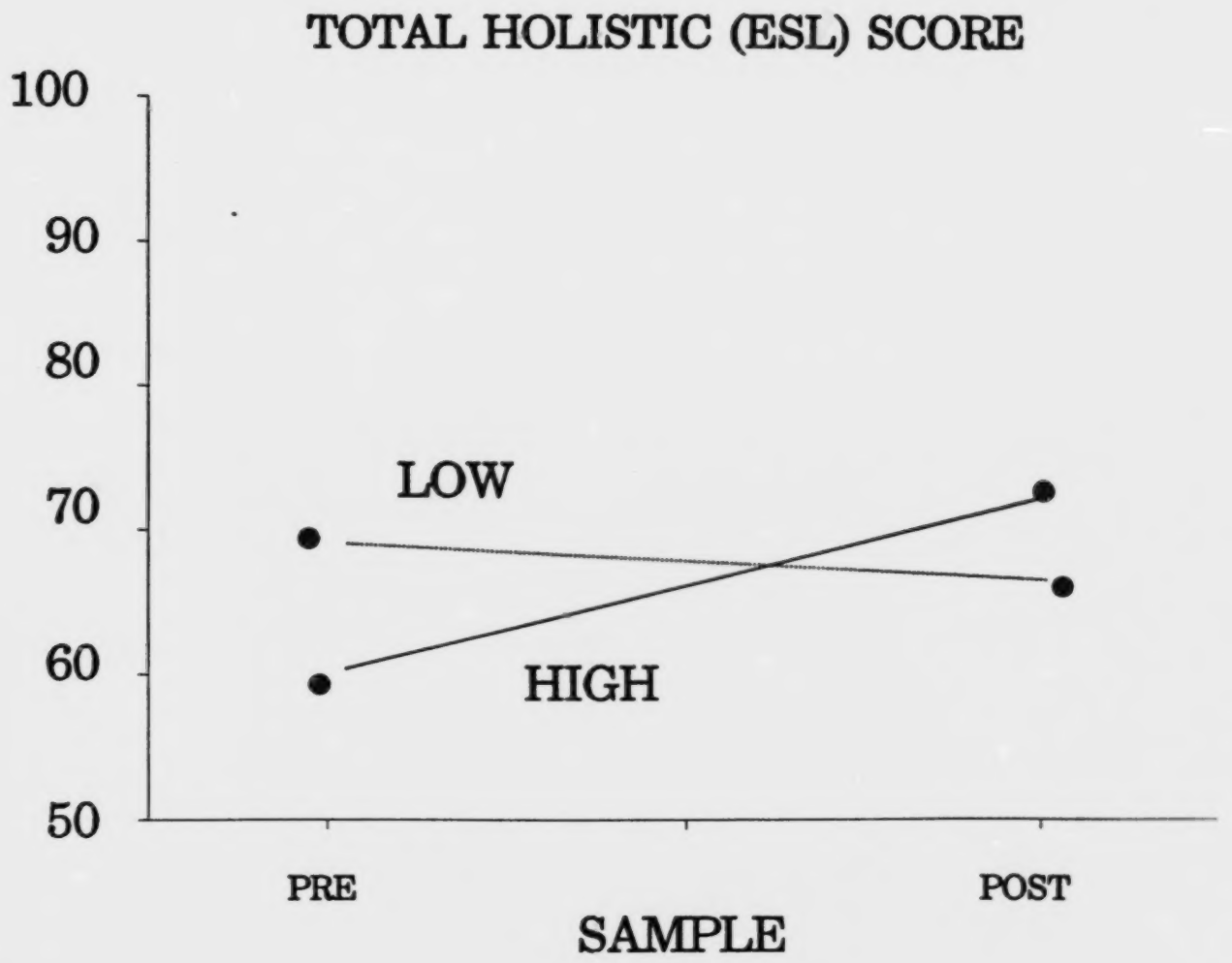

TOTAL HOLISTIC (ESL) SCORE
100
90
80
70
60
50
LOW
HIGH
PRE
POST
SAMPLE

FIGURE 5

FIGURE 6

CONNECTEDNESS

HEARING CHILDREN

LOCAL CONNECTION

There are many things about ice skating that make it fun and exciting.

The fun thing about ice skating is. . .

REMOTE CONNECTION

There are many things about ice skating that make it fun and exciting.

Another fun thing about ice skating is . . .

FAILED CONNECTION

Ice skating is fun because you don't fall all the time.

You can fall and break a leg.

McCutchen & Perfetti, 1982

FIGURE 7

CONNECTEDNESS
DEAF CHILDREN

LOCAL CONNECTION

There was a green clay of mountains, land, lake, hill, bay, divide, and volcano lake.

All of that stuff was in one big clay.

REMOTE CONNECTION

R., Q., and I was working on topographic.

•
•
•

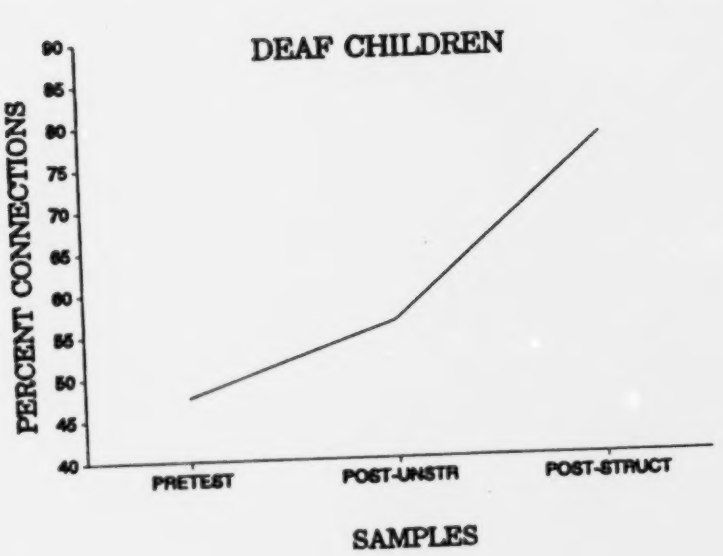
Then we make a key on different thing on clay.

FAILED CONNECTION

But we mistake of the contour lines and we don't know what to do.

We feel to more contour lines.

LOCAL CONNECTIONS



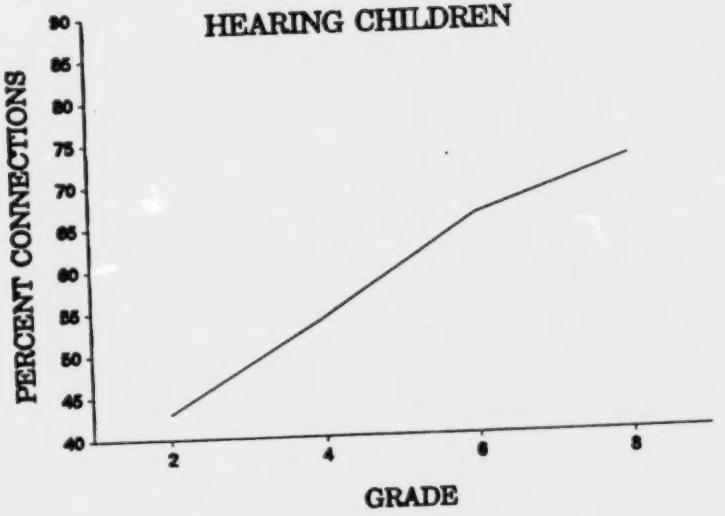
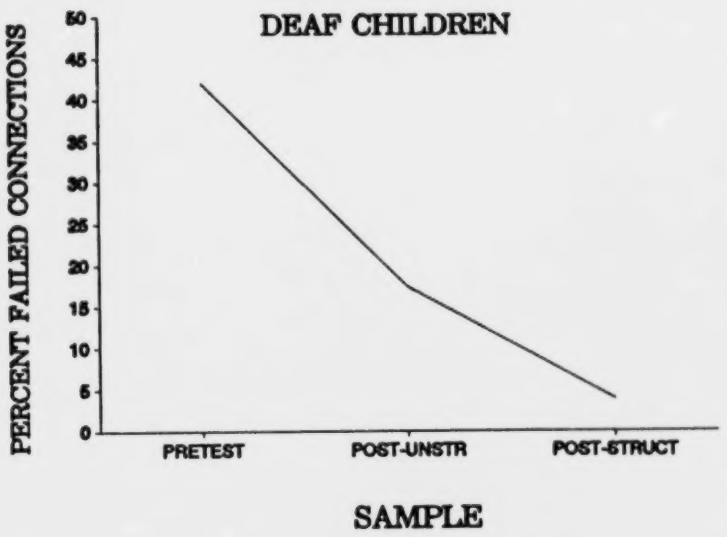


FIGURE 8

McCutchen & Perfetti, 1982

FAILED CONNECTIONS



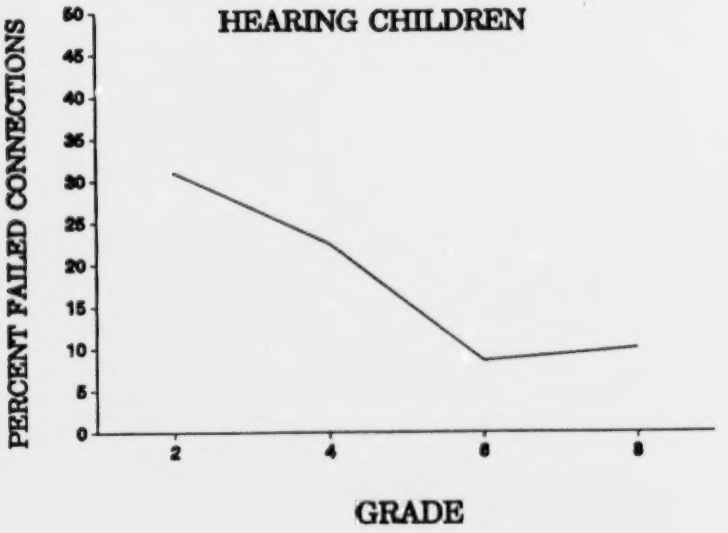


FIGURE 9

McCutchen & Perfetti, 1982